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MUON SHIELD FOR THE TEVATRON (II)

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I. Introduction

A number of interesting suggestions have been made regarding the previous studies on muon shield arrangements in the Neutrino Area for the Tevatron[1]. In this report I will discuss two additional shield arrangements which are very useful in estimating the muon background rates for slightly modified shield arrangements. The first arrangement has a 70m long open space between the beam dump and the upstream end of the iron shield. This space corresponds to Enclosure 100. In the previous studies the muon shield started from the beam dump and there was no free space downstream of the dump. In the second arrangement, an iron shield block is placed at the downstream end of the shield so that the iron block can give a shadow to neutrino detectors downstream of the shield. The latter can greatly simplify construction of the muon shield. Other arrangements in which an iron block is placed at the upstream end of the shield causes difficult construction problems if the N7/5/3 beam line must be retained after the shield construction is completed.

II. A 70m Open Space Downstream of the Beam Dump

A schematic drawing of the shield arrangement with a 70m open space downstream of the beam dump is shown in Figure 1. Figure 2 shows radial distributions of muon backgrounds as a function of the radius at neutrino detectors for the iron shield radius of 1.75m with no decay pipe iron shield and for the iron shield radius of 1.25m with a decay pipe iron shield of 0.75m outer radius and 300m length. Also shown are muon backgrounds for the same shield arrangements as above except without the 70m open space (Figures 5 and 10 in Reference 1). The incident proton energy was 1000 GeV. Stefanski-White's parametrization[2] was used for positive pion production for the bare target beam. Contributions from the negative pion decay and other processes were neglected. Energy losses due to atomic collisions and pion productions only were considered in the present Monte Carlo calculations. Bremsstrahlungs and nuclear interactions were not included.

Muon background rates increased by a factor of roughly 10 with the 70m open space. In order to maintain the same background level as for the arrangements without the 70m open space, the iron shield radius must be increased by about 20cm for the shield arrangement with no decay pipe iron shield (see Figure 4 in Reference 1). This is because most muons which contribute to backgrounds for this arrangement have an average angle of about 3 mrad after the decay pipe. In the case of the shield arrangement with the decay pipe iron shield, the muon backgrounds which are caused by an open space downstream of the beam dump can be suppressed by, 1) increasing the outer radius of the decay pipe iron shield (see Figures 9 and 10 in Reference 1); 2) increasing the radius of the iron shield; or 3) increasing the length of the decay pipe iron shield as shown in Figure 2.

III. Iron Shield at the Downstream End of the Shield

The schematic drawing is shown in Figure 3. Detectors are placed downstream of the shield at intervals of 50m. Since the soil and iron have different energy dependences of dE/dx, this arrangement requires about 10% longer iron shield. Figures 4 and 5 show radial distributions of muon backgrounds at detectors placed 0, 50, and 100m downstream of the shield for the iron shield radius of 1.8m and 2.1m, respectively. Although a small radius area seems to have low muon backgrounds right after the shield due to a shadow effect from the iron block, this arrangement is clearly undesirable.

IV. Conclusions

The iron shield block must be placed at the upstream end of the shield. If we introduce any open spaces followed by the iron shield block, the iron shield radius must be increased roughly by the length of the open spaces times 0.003, or a special arrangement such as an extension of the decay pipe iron shield must be made.

Many people gave me interesting suggestions. Valuable discussions with Neutrino staff members are greatly acknowledged.

References

1. S.Mori, Muon Shield for the Tevatron at Fermilab, Fermilab Internal Report, TM-790, May 1978.
2. R.Stefanski and H.White, Jr., Neutrino Flux Distributions, Fermilab Internal Report, FN-292, 1976.

Figure Captions

Figure 1: The schematic drawing of the shield arrangement with a 70m open space downstream of the beam dump.

Figure 2: Radial distributions of muon backgrounds for the iron shield radius of 1.75m with no decay pipe iron shield and for the iron shield radius of 1.25m with a decay pipe iron shield of 0.75m outer radius and 300m length, with and without a 70m open space downstream of the beam dump.

Figure 3: The schematic drawing of the shield arrangement in which the iron shield block is placed at the downstream end of the shield.

Figure 4: Radial distributions of muon backgrounds at detectors placed 0, 50, and 100m downstream of the shield for the iron shield radius of 1.8m.

Figure 5: Radial distributions of muon backgrounds at detectors placed 0, 50, and 100m downstream of the shield for the iron shield radius of 2.1m.

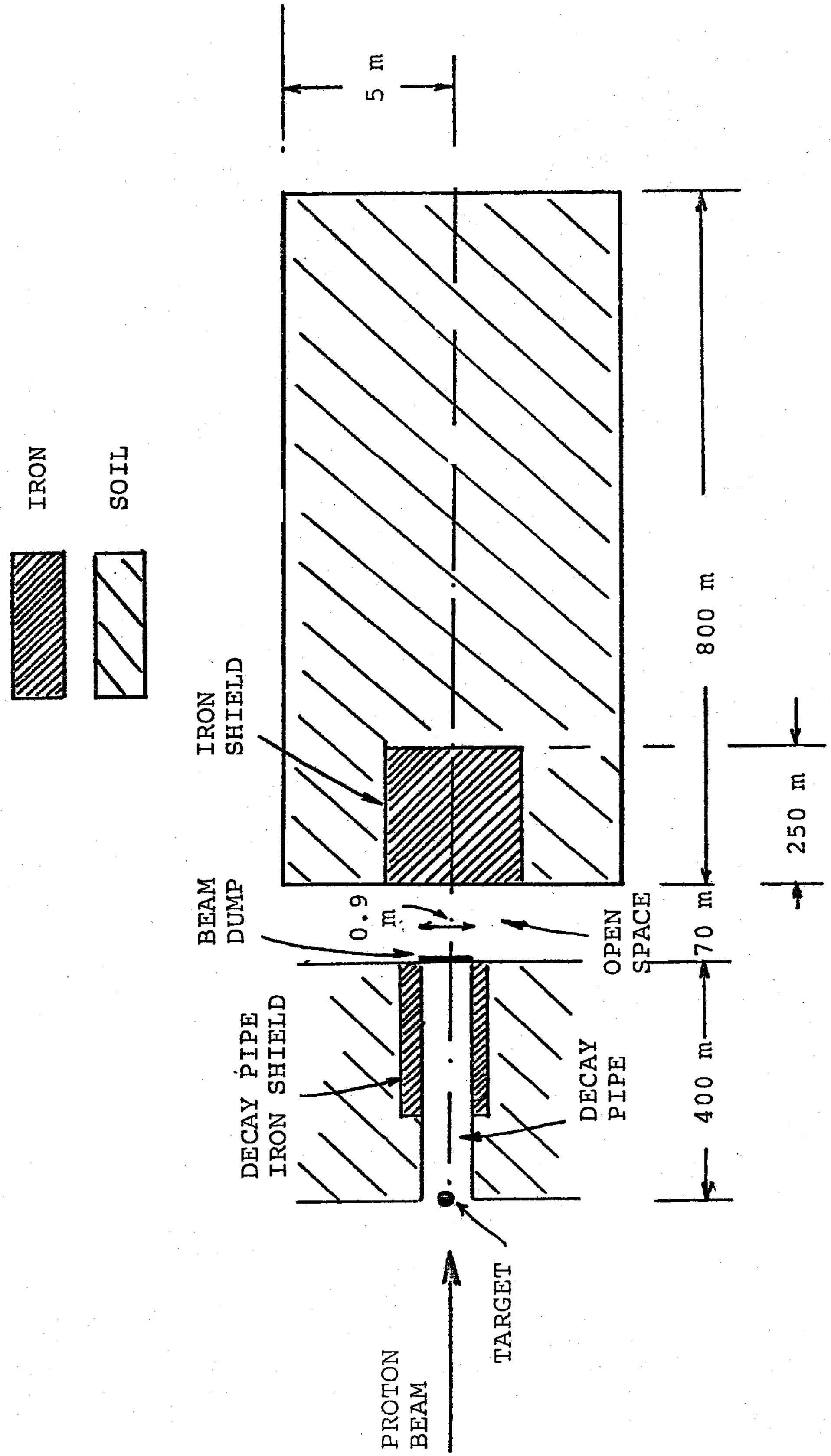
IRON
SOIL
5 m
IRON SHIELD
800 m
250 m
BEAM DUMP
0.9 m
OPEN SPACE
70 m
DECAY PIPE IRON SHIELD
DECAY PIPE
400 m
TARGET
PROTON BEAM

Figure 1.

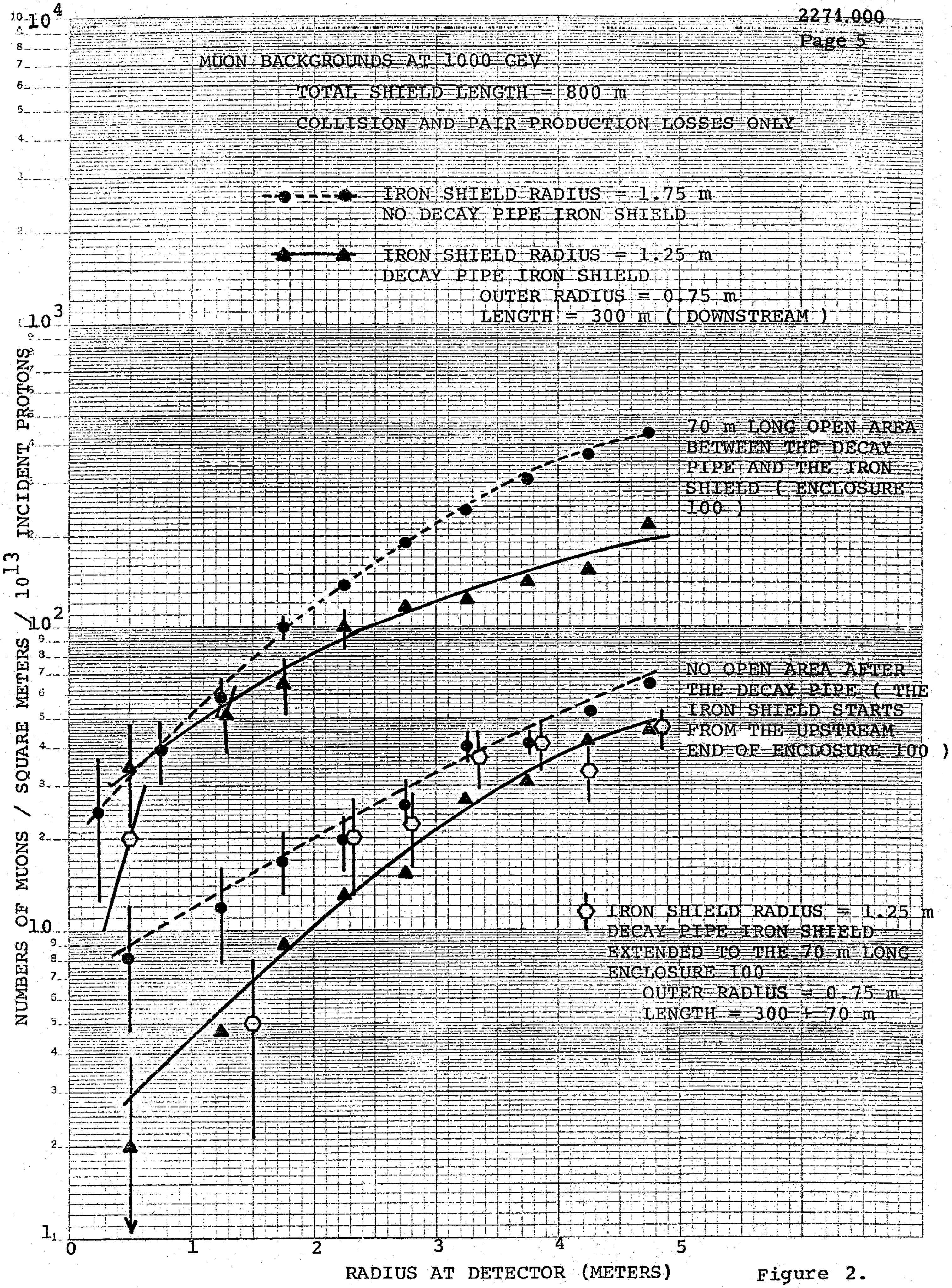
MUON BACKGROUNDS AT 1000 GEV
TOTAL SHIELD LENGTH = 800 m
COLLISION AND PAIR PRODUCTION LOSSES ONLY
IRON SHIELD RADIUS = 1.75 m
NO DECAY PIPE IRON SHIELD
IRON SHIELD RADIUS = 1.25 m
DECAY PIPE IRON SHIELD
OUTER RADIUS = 0.75 m
LENGTH = 300 m (DOWNSTREAM)
70 m LONG OPEN AREA BETWEEN THE DECAY PIPE AND THE IRON SHIELD (ENCLOSURE 100)
NO OPEN AREA AFTER THE DECAY PIPE (THE IRON SHIELD STARTS FROM THE UPSTREAM END OF ENCLOSURE 100)
IRON SHIELD RADIUS = 1.25 m
DECAY PIPE IRON SHIELD EXTENDED TO THE 70 m LONG ENCLOSURE 100
OUTER RADIUS = 0.75 m
LENGTH = 300 + 70 m
NUMBERS OF MUONS / SQUARE METERS / 10^13 INCIDENT PROTONS
RADIUS AT DETECTOR (METERS)
10^4
10^3
10^2
10.
1
0
1
2
3
4
5

Figure 2.

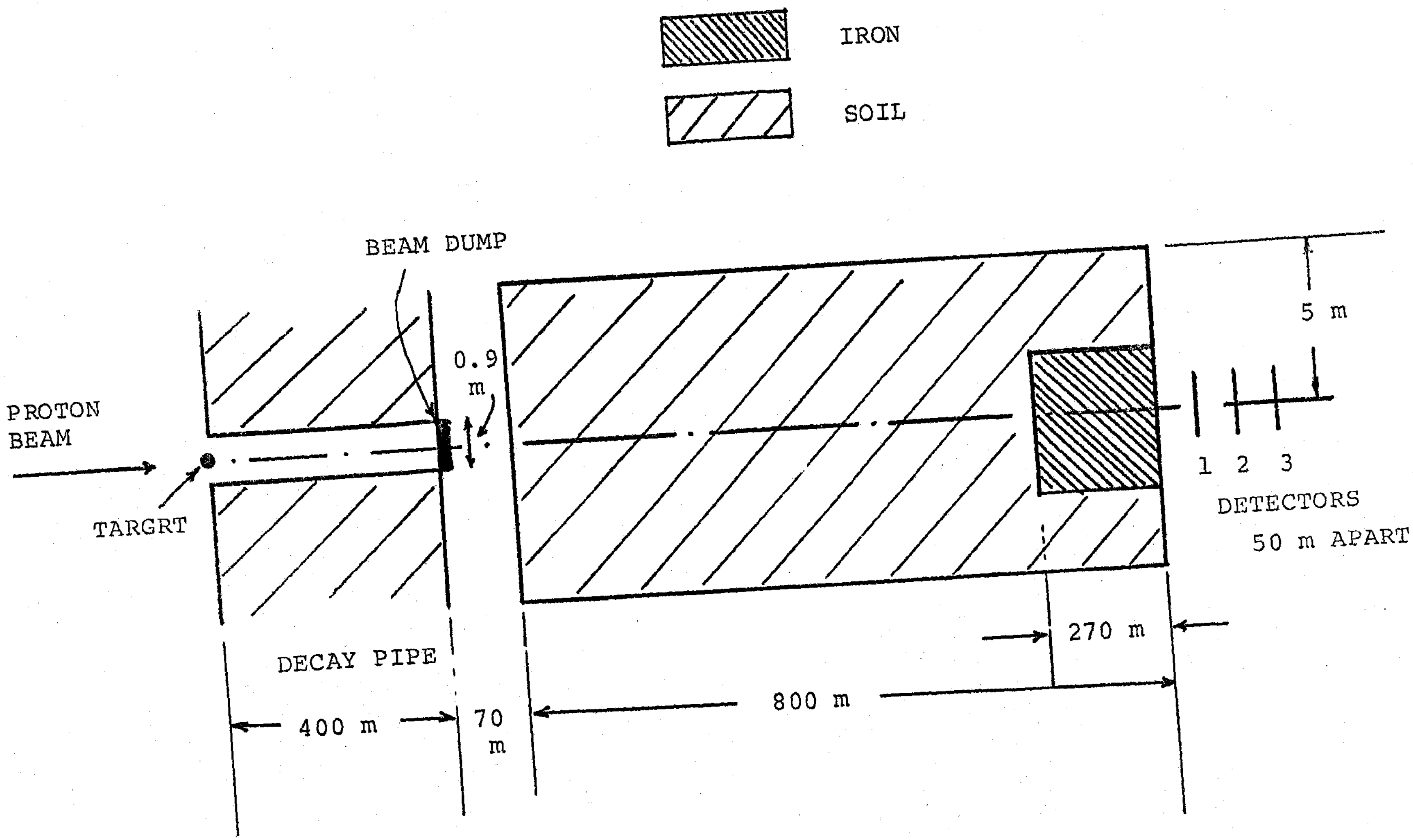
IRON
SOIL
BEAM DUMP
0.9
m
5 m
PROTON
BEAM
TARGRT
1 2 3
DETECTORS
50 m APART
270 m
DECAY PIPE
400 m
70
m
800 m

Figure 3.

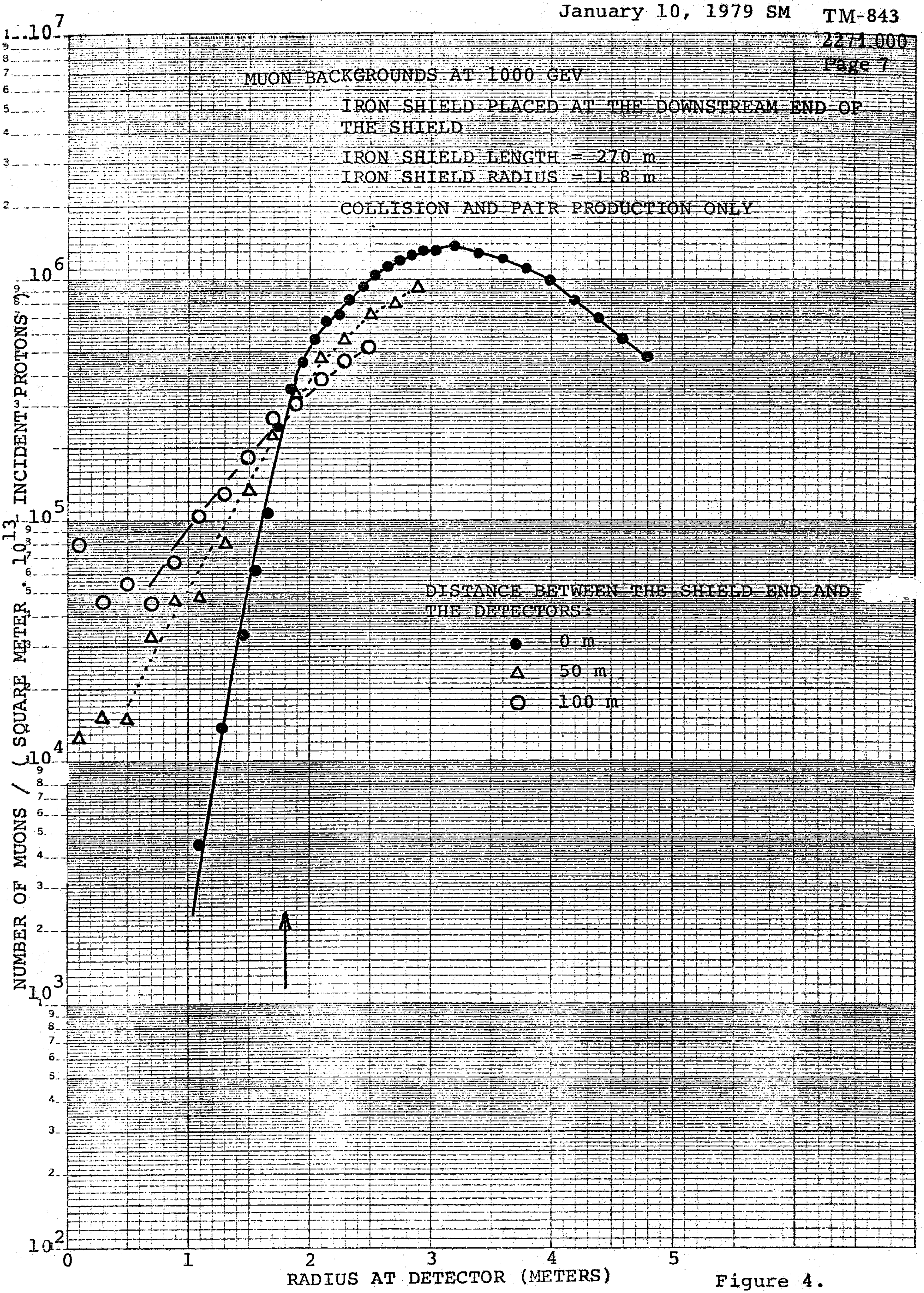
MUON BACKGROUNDS AT 1000 GEV
IRON SHIELD PLACED AT THE DOWNSTREAM END OF THE SHIELD
IRON SHIELD LENGTH = 270 m
IRON SHIELD RADIUS = 1.8 m
COLLISION AND PAIR PRODUCTION ONLY
DISTANCE BETWEEN THE SHIELD END AND THE DETECTORS:
0 m
50 m
100 m
NUMBER OF MUONS / (SQUARE METER · 10^{13} INCIDENT PROTONS)
RADIUS AT DETECTOR (METERS)
10^7
10^6
10^5
10^4
10^3
10^2
0
1
2
3
4
5

Figure 4.

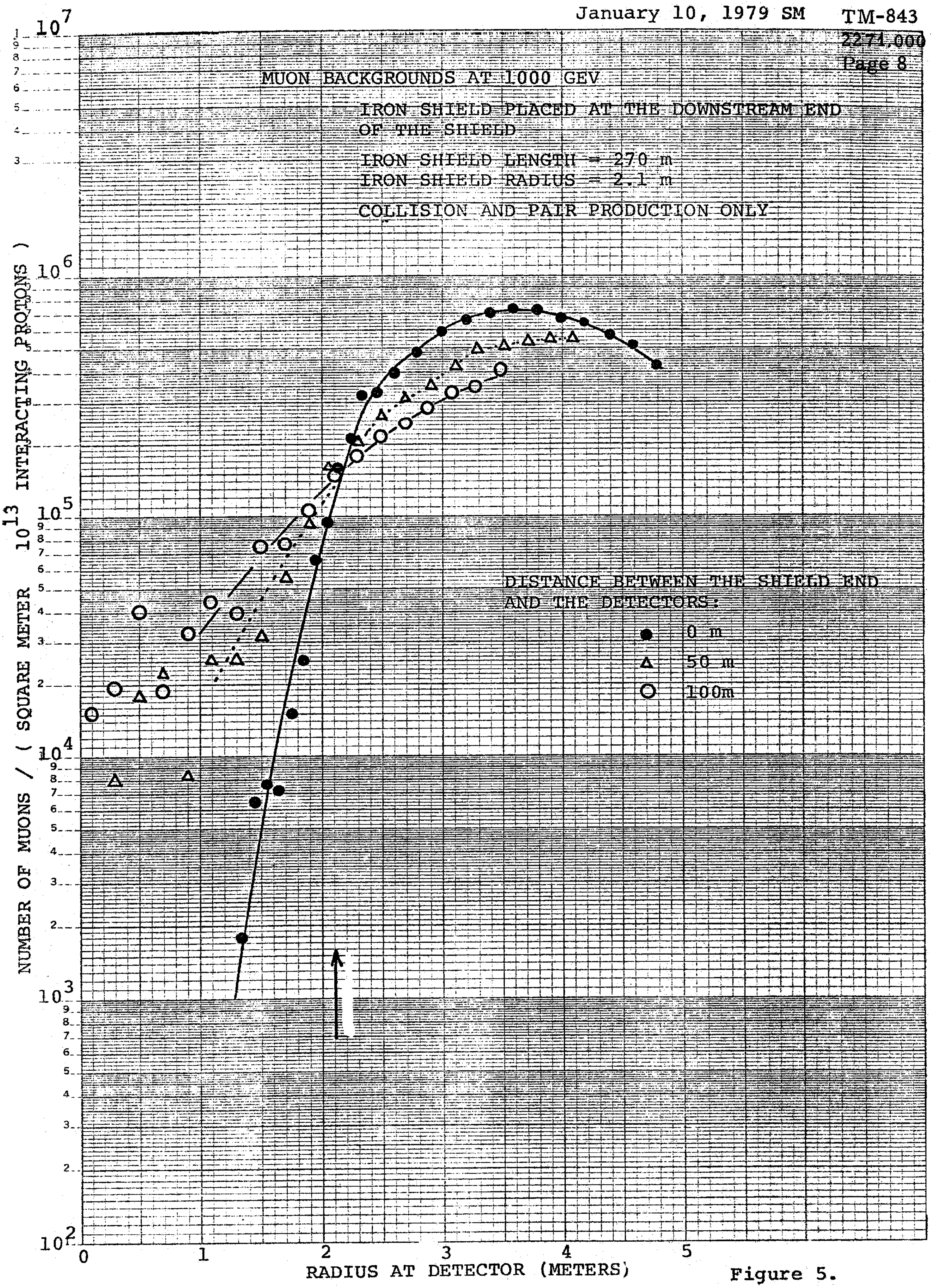
MUON BACKGROUNDS AT 1000 GEV
IRON SHIELD PLACED AT THE DOWNSTREAM END OF THE SHIELD
IRON SHIELD LENGTH = 270 m
IRON SHIELD RADIUS = 2.1 m
COLLISION AND PAIR PRODUCTION ONLY
DISTANCE BETWEEN THE SHIELD END AND THE DETECTORS:
0 m
50 m
100m
NUMBER OF MUONS / (SQUARE METER 10^{13} INTERACTING PROTONS)
RADIUS AT DETECTOR (METERS)
10^7
10^6
10^5
10^4
10^3
10^2
0
1
2
3
4
5

Figure 5.